

**On the relationship of infection by hookworm to the incidence of morbidity and mortality in 22,842 men of the United States army at Camp Bowie, Texas, from October 1917, to April 1918. By Major Charles A. Kofoid and First Lieutenant John P. Tucker.**

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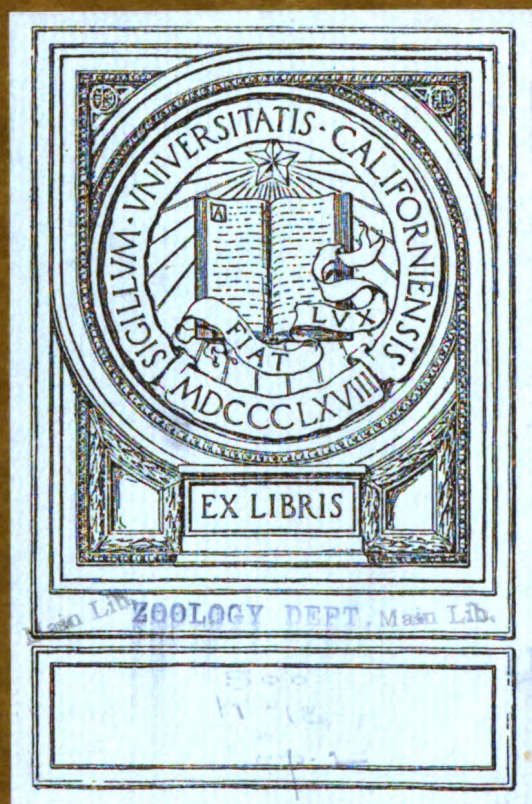
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TO THE INCIDENCE OF MORBIDITY AND MORTALITY  
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CALIFORNIA

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ABSTRACT

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IN 22,842 MEN OF THE UNITED STATES ARMY AT  
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TO APRIL 1918.

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INTRODUCTION.

The following investigation of the quantitative effect of the presence of infection by hookworm upon the incidence of disease and the resulting burden of sickness, as represented by regimental reports of sick call and by hospital admissions, is based upon data collected at Camp Bowie, Texas, in April, 1918, by the Laboratory Car Metchnikoff, Major Charles A. Kofoid, Sanitary Corps, U. S. A., in charge. The data were collected in the course of a hookworm survey of the 36th Division, U. S. Army, incorporating former National Guard organizations from Texas and Oklahoma, and brought to its full complement by infiltration of recruits from the same general localities. It had almost reached its full numbers at the time of the survey. The total number of men on rosters furnished was 25,224, including some units belonging to the Camp proper, rather than to the Division. Of these, 1,565 or 6 per cent. were not surveyed. Of the 23,659 examined 2,921 or 12.3 per cent. were found to be infected with hookworm, presumably *Necator americanus* in most cases, as there were relatively few men of European birth in the Division. The greater part of these infections were light and not attended by the manifest clinical symptoms constituting hookworm disease.

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In one regiment only, the 143d Infantry, recruited mainly from Eastern and Southern Texas, did the infection exceed 20 per cent., rising in that organization to 30 per cent., and in companies C, D, and E thereof, to 68, 63, and 54 per cent. respectively.

The aim of the investigation was to determine by a statistical study the extent of sickness in the Division, as recorded in the regimental sick call and in the hospital admissions, in the two groups of men separated by our hookworm survey, namely the men with hookworm and those in which this had not been detected, and to find a quantitative expression for the increased burden of sickness which this infection was reputed to place upon the army.

The Camp records, showing the incidence of sickness, which were used in the compilation of our data, covered the period from October 1, 1917, to about April 15, 1919, and are thus partly representative in that they cover a period of time sufficient to afford an adequate volume of data. They include the winter season with its incidence of respiratory diseases, and the measles-pneumonia epidemic of the winter of 1917-1918.

#### ACKNOWLEDGMENTS.

This investigation was made possible only by the cooperation of many officers and enlisted men. The multitude of the data involved, and the necessity of supervision and inspection, arising from the varied nature of the original data, have required the assistance of collaborators. The initiation of the investigation was due to the prevalent opinion at Camp Bowie that regiments from the area of heavy hookworm infection had been particularly subject to sickness, lax in discipline, and of lowered efficiency. The lively interest of Brig. General Greble in Command of Camp Bowie, and the efficient cooperation of the Division Surgeon, Colonel Metcalf, and of Colonel Hansen of the Base Hospital, greatly facilitated securing the original data in satisfactory form for use.

Especial mention should be made of the services of Captain M. A. Barber, Sanitary Corps, then of the Laboratory Car Metchnikoff, for his deep interest in and efficient supervision of the preliminary assembling and tabulation of the original data. In this work 1st Lieutenant George H. Bigelow, M. C., 1st Lieutenant E. S. Maxwell, M. C., 1st Lieutenant R. S. Robinson, M. C., 1st Lieutenant H. B. Yocom, S. C., and Sergeant T. I. Storer of the Laboratory Car Metchnikoff, gave efficient aid.

The final computations, tabulations and re-inspection of the data were made at the Army Laboratory, Port of Embarkation, by a group of technicians and enlisted men, drawn from the staff and personnel of the laboratory, under the direction of the authors. Much of the laborious assembling of the data has been done by Miss J. N. Wasserman and Miss M. Gimbel of this Laboratory.

#### METHODS.

The data for this investigation were compiled from two sources, the records of the Regimental Surgeon and of the Base Hospital, on cards, based on those used by Majors Siler and Cole (1917) in their hookworm survey of three regiments at Fort Sam Houston, Texas.

The form of the card is as follows:

Surname	Christian	Rank	Co.	Organization	Date enlisted	No.
Residence prior to enlistment		State	County		Town	
Occupation		Where spent last 10 yrs.		Orient?	Tropics?	
Height	Age		Clinical symptoms			
Previous treatment for hookworm.		When?				
Examination for hookworm:			No. of times on sick report:			
Date of sample:			Date and diagnosis:			
Date of examination:			Treated in hospital:		Diagnosis:	
Date of treatment:						
Date of reexamination:			Other parasites:			
Result of reexamination:						

These cards were filled out at the regimental infirmaries, under the supervision of the regimental surgeons, in all sections except those referring to the results of examination, clinical symptoms, and hospital record. The results of the examination were entered on the card by the examiner at the laboratory, and the hospital record was compiled from the data on file at the Base Hospital.



The entry for "times on sick report" was made in number of days, but the hospital record was entered only as "admissions or times sent to the hospital."

In a number of cases, not exceeding 5 per cent. of the records for sick call, the data returned were in indefinite terms such as "continually," "chronic," "many times," "repeatedly," "several times," etc. In all such entries we have arbitrarily set the numerical value of the sick calls at 10, this number being much below the actual number of calls recorded, of men who might be characterized by the phrases that we are interpreting.

#### THE PROBABLE ERROR.

In all statistical work the mathematical statement of the probability of error may be computed and expressed quantitatively, on the basis of the quantitative factors entering into the problem. In the investigation here reported certain other factors not expressed quantitatively in our data, so far exceed in importance the available quantitative data, that any formal computation of the probable error would be inadequate and perhaps misleading.

Since the reports for sick call are made by different regimental surgeons, and the policy in the matter of reporting men on sick call varies with the individual surgeon and the pressure of military exigencies, the data are subject in this respect to an indeterminate variable. The nature of this variable is such that it tends in the main to reduce the sick calls, and since our evidence shows that the sick calls are greater among men infected with hookworm than in those in whom it was not detected, the net result of this variable will be to reduce the volume of the evidence for the effect of hookworm, but not to change the direction of the differences detected.

Another source of error is that resulting from the transfer of men from organization to organization. In a changing military unit, such as a division in process of organization, the volume of the movement of men from the detention camp to their final allocation is considerable. Since the record of sick calls is a company record, and does not follow the man in transfer, it results that our data fail to include the sick calls and hospital records of men prior to the date of their last transfer. The clerical burden of determining the total record of sickness of every man in the existing system of medical records would have at once prevented this investigation, had it been thus attempted.

Our records therefore show only a part of the total sickness in the 36th Division. The part included in the different organizations varies with the number of transfers, their date, and the age of the organization. It is well known that the more efficient men of an organization are less liable to transfer. The net result of this tendency is that men with hookworm who are, as a rule, less efficient, are more liable to transfer, and in consequence their accumulated sick call is left behind, and their previous hospital record could not be recorded against them in our inspection of the hospital files, because of the absence of any clue readily available, as to their present affiliation. As in the case of the variability of standards of sick call, so also here, this incompleteness in our data tends to reduce the volume of evidence for the deleterious effect of hookworm, but not to change the direction of the differences.

For these main reasons, as well as for others of relatively minor significance, our data represent the total burden of sickness inadequately and disproportionately less adequately for men infected with hookworm than for men in whom the infection was not detected. Our computations and conclusions therefore do not overstate the volume of the burden resulting from hookworm.

Another factor which operates to decrease the contrast in sickness between men with hookworm and men in whom it was not detected, results from the fact that not all men with hookworm were detected. A single examination is insufficient to detect all infections. Tests made by Lieutenant Kantor on men in the hospital at Fort Oglethorpe, Ga., showed that the first examination revealed only 61 per cent. of the infections, detected on five examinations, among men in whom infections were presumably as a rule heavier than in troops from Texas and Oklahoma. The average percentage of infection in Camp Bowie was 12.3 per cent. Many of the stools examined were very lightly infected. Infections in which male worms only are present are not detected by the methods used in stool examination. In addition many of the men of Camp Bowie came from the outer fringes of the hookworm area, and were in the period of life in which the hookworms entering the body in the barefoot days of boyhood are dying of old age. This is estimated at seven years, for males, and ten for female worms. The preponderance of light infections in these troops is therefore to be expected.

In the course of our survey at Camp Bowie there were a number of instances of men negative or positive on one examination for whom

the finding was reversed at the second examination. In 14 instances of examination at autopsy, of men previously reported as negative on the stool examination, Major Barber at Camp Jackson, S. C., found 8 or 57 per cent. carrying a light infection, as shown by an average of 9 worms per man, as compared with 85 worms in 4 previously reported positives. While it is hardly probable that either 39 per cent. or 57 per cent. of our negatives at Camp Bowie were even lightly infected, it is certain that an unknown smaller number of them were so infected. These men are included in our negatives, and whatever excess of sickness they may have had, as a result of the undetected infection, reduces the contrast in our findings between the men with hookworm and those in whom we did not detect it.

These considerations, as a whole, make it highly probable, if not certain, that the burden of sickness upon the army, and upon the communities in the hookworm area from which these troops came, which is fostered, if not created, by hookworm, was in excess of that which this investigation has revealed. The authors are fully aware of the inadequacy of the data and of the very complex nature of the problem on which they bear. We have attempted in face of these difficulties to isolate this factor, and to determine its probable potency in so far as the data will permit.

It should be distinctly noted that we fully recognize that hookworm is not the sole and only potent factor involved. Malaria doubtless enters into consideration to some extent in troops from Southeastern Texas, but a large part of the area from which the 36th Division came is relatively free from this plague. There are only 24 cases of active malaria on record for the 22,842 men included in our investigation.

✓ { Hookworm is only one element in a vicious circle of interacting factors including among others, lack of sanitation in rural districts, the selective action of the movement of population to cities, the hereditary segregation of classes resulting therefrom, the lack of exposure in childhood to infectious and contagious diseases which results from the isolation of individuals in rural communities, and parasitism by hookworm and malaria, persistent chronic infections. All of these factors cooperate to foster and maintain the higher sick rate which we have here correlated with the infection by hookworm alone. The elimination of this infection presumably tends to reduce this burden of sickness, and the extent of this reduction would in time constitute a rough measure of the volume of burden contributed by hookworm. In individual cases of treatment and cure in the army this reduction

is patent, but no quantitative measure of the result in numbers, adequate to afford a test, is available.

#### PRESENTATION OF THE STATISTICAL DATA.

The statistical data presented are drawn from the various regiments and units comprising the 36th Division. Each organization has been worked out in detail in Table I, with comparative tabulation of pertinent data, those with stools in which ova of hookworm were detected, against those in which ova were not found. The figures on the so-called negative side are taken as the normal upon which computations of percentages have been made.

On the left and right appear respectively, data dealing with men in whose stools hookworm ova were not detected and those in which ova were found. The first two columns on the right of the heavy line contain the total number of men in whom hookworm was detected and the per cent. infected among the whole number examined. These numbers are of necessity larger than those in the next column, for sick data were not obtainable on many of the positives. The total number of men with ova in their stools is in excess of those whose sick and hospital records were available for use.

Corresponding columns on the left and right deal with total number of men with data, total number of men sick, and total number of sick calls and hospital admissions and computation of the same per man in each case. If a man appeared four times on sick call, the number four (4) would be added to the total sick calls, but he would be recorded in the sick column only once. Also if he appeared twice on sick call and once in hospital, his record would appear as two and one in these columns, but only once as sick. Using this method, we have the total number of men who have been ill, distinct from the number of times they have been on sick call or in the hospital.

The last three columns on the right deal with the per cent. of increase or decrease of admissions to hospital, total sick calls, and total number of men sick among the positives, as compared with the so-called negatives. The figures are self-explanatory, if we remember that computations use the negative side as a fair representation of the average normal.

Reports of two typical regiments are given in detail, the 141st Infantry (Table I) and the 143d Infantry (Table II). These show how company and regimental totals were obtained by a study of each individual in each company. Tables III to V deal with the Division



as a whole. Table III is a grand summary of all the regiments and the other units, with additional mortality statistics for each unit. The next (Table IV) deals with the incidence of various diseases occurring in positive and so-called negative individuals respectively, and the last (Table V) is a comparison of mortality and morbidity in so-called negatives and positives for hookworm in the Division as a whole.

The facts brought out show definite trends towards important and definite conclusions. These are the more accurate and the more significant by reason of the great mass of data. Not only in individual regiments, companies, or units, but in the Division as a whole, the striking influence of hookworm infection is definitely directed against army efficiency. Thus certain fundamental problems arise:

1. What is the influence of hookworm infection on the incidence of sickness, number of daily sick calls, and the hospital admissions in this Division?

2. What influence has hookworm infection on the chronicity of minor ailments?

3. Does hookworm infection influence the severity of infectious diseases?

4. Does hookworm infection increase susceptibility to disease?

5. What bearing has hookworm infection on mortality?

6. What influence has hookworm infection on army efficiency?

Attention is directed to the tabulated data and conclusions for a consideration of these questions.

#### MORBIDITY IN THE 141ST INFANTRY.

In the 141st Infantry, a lightly infected regiment with only 11.7 per cent. of hookworm infection, data are recorded on 2,263 men. This does not comprise the entire number examined, but those whose sick and hospital records were obtainable. On the left hand side of the table (Table I) 1,974 men are reported showing no ova in one stool examination. Of these 851 were sick at some time or other, giving 315 admissions to the hospital and 888 appearances on sick call. In this same organization, we have records on 289 positives with 164 sick, 48 hospital admissions and 178 sick calls. The increase of positives over so-called negatives is 31.6 per cent. in men sick, 56.2 per cent. in hospital admissions, and 108.1 per cent. in sick calls. All of the individual companies in the regiment show corresponding gains in one or more of the three columns, gains in disease being

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TABLE I.  
*Incidence of sick call and hospital admission in men with hookworm infection, as compared with those in whom this was not detected, in the 141st Infantry, Camp Bowie, Texas.*

Co.	No hookworm detected.										Hookworm positive.									
	Total men.	No. sick.	Times in hospital.			Total men with hookworm.	Per cent. infected.	Total men with sick data.	No. sick.	Times in hospital.			Times on sick call.			Per cent. increase or decrease in hospital.	Per cent. increase or decrease on sick call.	Per cent. increase or decrease in number of men sick.		
			Total no.	No. per man.	Total no. call.					Total no.	No. per man.	Total no. call.	Total no.	No. per man.	Total no. call.					
A.....	195	53	14	0.07	67	0.34	2	1.1	2	1	0	0	1	0.5	-100.0	47.06	84.0			
B.....	118	55	24	0.2	56	0.47	10	7.8	10	6	0	0	6	0.6	-100.0	27.66	28.7			
C.....	166	94	55	0.33	86	0.52	10	5.2	10	6	2	0.2	5	0.5	-39.39	-3.85	5.9			
D.....	127	62	18	0.14	73	0.57	11	7.3	11	4	2	0.18	7	0.64	28.57	12.28	-25.5			
E.....	116	51	18	0.16	56	0.48	16	11.8	16	10	4	0.25	8	0.5	56.25	4.17	42.2			
F.....	116	58	20	0.17	64	0.55	10	7.5	10	8	2	0.2	10	1.0	17.65	81.81	60.0			
G.....	99	61	23	0.23	56	0.56	8	6.2	8	4	1	0.12	6	0.75	-47.83	33.93	-18.8			
H.....	83	41	14	0.17	42	0.5	25	17.7	25	16	3	0.12	17	0.68	-29.4	36.0	29.5			
I.....	116	67	25	0.21	65	0.56	25	12.0	22	15	6	0.27	20	0.91	28.57	62.5	18.0			
K.....	97	49	10	0.1	57	0.59	9	7.5	9	4	0	0	6	0.67	-100.0	13.56	-12.0			
L.....	101	64	28	0.28	64	0.63	68	32.8	68	48	15	0.22	45	0.66	-21.43	4.76	11.4			
M.....	143	55	18	0.12	70	0.49	28	15.2	28	17	8	0.28	23	0.82	133.3	67.35	57.8			
Hdq.....	193	36	6	0.03	38	0.19	32	12.5	29	2	1	0.03	1	0.03	0.0	-84.21	-63.0			
M.G.....	127	61	21	0.16	39	0.30	19	12.0	19	14	4	0.21	12	0.63	31.25	110.0	53.4			
Sup.....	122	34	14	0.11	48	0.39	19	12.7	19	8	0	0	10	0.53	-100.0	35.89	51.1			
M.D.....	55	10	7	0.13	7	0.13	3	4.5	3	1	0	0	1	0.33	-100.0	153.84	83.3			
Total....	1,974	851	315	0.16	888	0.45	295	11.7	289	164	48	0.25	178	0.94	56.25	108.08	31.6			

shown in thirty-three of the forty-eight entries on the positive side. Yet various factors come in to change the balance here and there without materially affecting the direction of the difference in the regiment as a whole.

In Company A, only two positives are recorded with no admissions to hospital and only one sick call. Here the so-called negatives have a gain of 100 per cent. in hospital admissions. Yet obviously, with only two positives against 195 with no ova in stools, no great significance can be placed on this particular case. Doubtless individual hookworm infections in this company were of light intensity, for its men came from lightly infected districts. Records show that 65 per cent. were recruited from El Paso County, Texas, where the percentage of men of the Division from this county found to be infected in 404 examinations was only 4.4 per cent. Of the other counties from which the men of this company were drawn approximately 90 per cent. are lightly infected regions.

The increase of severity in disease among these positive men is indicated by the higher percentage of hospital admissions among them, as compared with the percentage of men sick, the whole regiment giving 31.6 per cent. men sick above the normal so-called negatives, while the hospital admissions show 56.25 per cent. increase. The difference, 24.65 per cent., shows that there is an actual increase in severity of disease among men positive for hookworm.

The same principle applies in considering chronicity of minor ailments, for where percentage of sick calls exceed percentage of men sick, minor ailments are shown to have caused more sick calls and are more chronic. The sick call shows 108.1 per cent. increase in positives above normal, as represented by so-called negatives, and is 76.5 per cent. higher than the increase in men sick. That is, there are more chronic illnesses among men carrying the infection than among the men in whom hookworm was not detected.

#### MORBIDITY IN THE 143D INFANTRY.

This was a heavily infected regiment having no less than 30 per cent. infections. Consideration of Table II, containing data on the 143d Infantry shows the same direction of difference, as that in the 141st Infantry. Here the general hookworm infection is heavier throughout the regiment. In companies C, D, and E, the positives exceed in number those in whose stool no ova were detected. Each of these companies shows a definite increase in the percentage of men

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TABLE II.

*Incidence of sick call and hospital admission in men with hookworm infections, as compared with those in whom this was not detected, in 143rd Infantry, Camp Bowie, Texas.*

Co.	No hookworm detected.					Hookworm positive.											
	Total men.	No. sick.	Times in hospital.		Times on sick call.	Total men with hookworm.	Per cent. infected.	Total men with sick data.	No. sick.	Times in hospital.		Times on sick call.		Per cent. increase or decrease in Hosp.	Per cent. increase or decrease or number of men sick.		
			Total No.	No. per man.						Total No.	No. per man.	Total No.	No. per man.				
A.....	130	70	47	0.35	93	0.71	33	20.7	33	17	12	0.36	32	0.97	2.86	36.6	- 4.3
B.....	130	76	78	0.6	524	4.03	67	33.9	64	39	42	0.66	243	3.8	10.0	- 5.71	4.2
C.....	56	34	22	0.41	62	1.15	131	68.0	131	88	57	0.43	177	1.35	4.88	21.7	10.7
D.....	73	54	30	0.41	582	7.97	122	62.9	122	115	67	0.55	1,290	10.6	34.15	33.0	27.4
E.....	87	36	39	0.45	173	1.99	94	54.3	94	46	43	0.46	230	2.45	2.22	23.11	18.3
F.....	98	85	40	0.41	155	1.58	83	46.0	83	80	29	0.35	149	1.8	- 14.63	13.92	11.1
G.....	141	121	61	0.43	442	3.13	40	21.8	39	32	21	0.54	127	3.26	25.58	4.15	- 4.4
H.....	152	131	51	0.33	421	2.77	54	25.7	54	45	25	0.46	156	2.89	39.39	4.33	- 3.3
I.....	182	165	82	0.45	596	3.27	24	11.9	24	18	5	0.21	81	3.37	- 53.3	3.06	- 17.3
K.....	118	59	38	0.32	462	3.91	86	43.9	86	58	39	0.45	293	3.4	40.62	- 13.04	34.9
L.....	176	123	83	0.47	306	1.73	28	13.4	28	16	12	0.43	47	1.68	- 8.51	- 2.89	- 18.2
M.....	183	90	88	0.48	182	0.99	17	8.4	17	4	5	0.3	0	0	- 37.5	- 100	- 52.1
Hdq.....	195	142	60	0.31	366	1.88	44	17.7	42	33	4	0.1	94	2.24	- 67.74	19.15	7.9
M.G.....	124	96	47	0.38	176	1.42	30	20.4	30	20	15	0.5	46	1.53	34.27	7.75	- 13.9
Sup.....	138	28	26	0.19	24	0.17	31	22.3	31	12	11	0.36	45	1.45	89.47	753.0	90.8
M.D.....	34	14	13	0.38	24	0.7	11	20.8	10	4	1	0.1	6	0.6	- 73.7	- 14.3	- 2.9
Total....	2,017	1,324	805	0.4	4,588	2.27	895	30.0	888	627	388	0.44	3,016	3.4	10.0	49.9	7.6



sick, of admission into the hospital, and number of sick calls in infected men as compared with the non-infected. As in the 141st Infantry, as a rule, the companies with the smaller number of positive infections show a smaller percentage of gain. The positive hookworm cases in companies C, D, E, and K, have an increase in men sick of 10.7 per cent., 27.4 per cent., 18.3 per cent., and 34.9 per cent. above those who showed no hookworm ova in one stool examination. Throughout the left or negative half of the table, we find also, a general increase in the total men sick, in hospital admissions, and in sick calls above the general level in the Division. It is reasonable to conclude that some hookworm cases in this regiment remained undiscovered by a single examination of stools for ova, and may have been potent in affecting the morbidity of the so-called negatives.

Company C, out of which 131 positives were recorded, with 56 men in whom no ova were discovered, comes largely from a particularly heavily infected region of Texas. Over 75 per cent. of the number were recruited from the following eight counties: Hardin, Orange, Jasper, Smith, Angelina, Sabine, Newton, and Tyler. In these, the rate of infection, based on combined records for Texas in the Southern Department, varied from 25.9 to 63.0 per cent., the lowest in Hardin and the highest in Tyler County. With over three fourths of the company coming from such hotbeds of hookworm infection, it is reasonable to conclude that a great many of the so-called negatives would have proved positive on further examination of the stools. Hence, any conclusions drawn from the hookworm side of the table are within the facts. No doubt figures on this side are much lower than the facts would really show, if all positives had been detected, yet in the regiment as a whole, sickness predominated much more among hookworm victims than those in whom it was not detected. The regiment had a total of 2,017 men, whose stools were reported negative, and 888 with sick data, who were positive with a total gain of 7.6 per cent. in men sick, 10 per cent. in hospital admissions and 49.9 per cent. on sick call. The greater severity of diseases in positives than in so-called negatives is indicated by the facts that with an increase of only 7.6 per cent. in men sick among positives, there is among them, an increase of 10 per cent. in hospital admissions. Greater chronicity of disease in positives as compared with negatives, so-called, is shown by the fact that with an increase of 7.6 per cent. in men sick, there is an increase of 49.9 per cent. in sick calls.

TABLE III.

*Incidence of sick call and hospital admission in men with hookworm, as compared with those in whom hookworm was not detected.*  
Summary of organizations—36th division, at Camp Bowie, Texas, October 1, 1917 to April 15, 1918.

Organisation.	No hookworm detected					Hookworm positive.													
	Total men.	No. sick.	Times in hos- pital.		Mortal- ity.*	Total men with hookworm.	Per cent. in- fected.	Total men with sick data.	No. sick.	Times in hospi- tal.		Times on sick call.		Per cent. increase or decrease		In no. of men sick.			
			Total no.	No. per man.						Total no.	No. per man.	on sick call.	In hosp.						
141 Inf.....	1,974	851	315	0.16	888	0.45	36	1.4	295	11.7	289	164	48	0.25	176	0.94	56.25	108.1	31.6
142 Inf.....	2,559	1,347	417	0.16	2,605	1.02	22	0.7	295	9.8	278	150	52	0.19	300	1.08	18.7	5.9	2.5
143 Inf.....	2,017	1,324	805	0.40	4,588	2.27	89	2.8	895	30.0	888	627	388	0.44	3,016	3.4	10.0	49.9	7.6
2,602 1,000	Inf.....	1,107	0.42	46	1.4	368	12.1	363	172	96	0.26	195	0.54	52.9	28.6	23.3			
1,238 833	131 F.A.....	1,508	1.22	13	0.9	143	10.5	142	112	51	0.36	268	1.89	259.0	54.9	78.9			
1,100 270	132 F.A.....	278	0.25	4	0.3	144	11.3	135	37	3	0.02	42	0.31	-33.3	24.0	-11.4			
1,293 480	133 F.A.....	614	0.47	20	1.3	163	11.2	162	78	15	0.09	113	0.7	28.6	48.9	29.7			
349 171	131 M.G.Bn.....	302	0.86	9	2.3	37	10.1	36	13	16	0.44	16	0.44	33.3	-48.8	-26.1			
639 239	132 M.G.Bn.....	288	0.45	2	0.3	63	9.1	63	23	16	0.25	43	0.68	177.8	51.1	-2.4			
513 318	133 M.G.Bn.....	496	0.97	7	1.0	140	21.2	132	88	46	0.35	146	1.11	34.6	14.4	7.5			
1,389 633	111 Eng.....	1,568	1.13	18	1.2	132	8.8	132	89	82	0.62	203	1.54	148.00	36.3	48.0			
796 238	111 Am.Tr.....	213	0.27	11	1.1	56	6.4	53	23	12	0.23	32	0.6	191.1	122.2	45.1			
382 212	111 F.S.Bn.....	1,079	2.82	3	0.6	40	9.6	39	25	11	0.28	153	3.92	12.0	39.0	15.5			
398 194	111 Sup.Tr.....	251	0.63	5	1.1	59	13.4	59	34	9	0.15	50	0.85	36.3	34.9	18.2			
177 115	111 M.P.....	202	1.14	1	0.2	63	17.8	63	55	18	0.28	95	1.51	7.7	32.4	34.4			
796 329	111 San.Tr.....	409	0.51	3	0.3	56	7.2	55	27	17	0.31	27	0.49	82.3	-3.9	18.8			
1,606 537	Miscellaneous .....	1,098	0.68	18	0.8	132	7.2	125	50	28	0.22	116	0.93	144.4	36.8	19.6			
Grand total ...	19,828	9,091	3,421	0.17	17,494	0.88	307	1.2	3,081	13.5	3,014	1,767	908	0.3	4,993	1.66	76.5	88.6	27.9

\* Per cent. mortality is based upon total men on roster.

## MORBIDITY IN THE 36TH DIVISION AS A WHOLE.

Data from the Division as a whole show in even a more convincing way the trend of affairs. In Table III all regimental and unit-totals have been added together with a calculation of resulting gain or loss in hospital admissions, sick calls and men sick. It represents 22,842 men who have had one stool examined for hookworm ova, and concerning whose health the sick cards and hospital records have been consulted. It includes a larger proportion of negatives from lightly infected organizations, from lightly infected regions, than in the case of the 141st and 143d Infantry which we have discussed above. The masking effect of undetected positives among the so-called negatives is therefore less in evidence in the Division, as a whole, than in the more heavily infected portions thereof. In the Division there were 3,014 positives and 19,828 men showing no ova on the stool examination. In other words, of men with sick data, 13.5 per cent. showed hookworm ova on one examination of the stool. Among these 13.5 per cent. positives, there was an increase of 27.9 per cent. in men sick,—over one fourth more, than in the so-called negatives. Hospital admissions are 76.5 per cent. higher in positives or over three fourths above the normal. Sick calls show 88.6 per cent. increase among hookworm hosts, which almost doubles the ratio among so-called negatives.

As in the 141st and 143d Infantry, the Division as a whole shows greater severity of disease among the positive hookworm cases for, whereas the increase in the positives over the so-called negatives in number of men sick is only 27.9 per cent. the increase in hospital admissions is 76.5 per cent. That is, the relative greater gain in admissions to hospital indicates an increase in severity of disease among positive hookworm cases, as compared with the so-called negatives. Likewise chronicity of disease is greater in positives, for the number of sick calls shows a gain of 88.6 per cent., while the number of men sick shows a gain of only 27.9 per cent. in the positives. The much greater gain in number of sick calls, per man, among positives, as compared with the so-called negatives, indicates that in the former diseases are much more chronic in character. This coincides with the data recorded on the several regiments and units of the division.

It is obvious that in a summary of this extent, minor variations in the direction of difference among companies or regiments and units, become, by preponderance in one direction, less and less significant. Occasional divergences are bound to exist among sick and hospital

records, as a result of the varying thoroughness of work done by the regimental surgeons and their staff. Yet in the totals, these differences become submerged by the weight of accurate records. Hence, the striking figures which appear in the grand summary of the whole division only repeat more forcibly the trend of the data in its various units. That is, sickness, whether mild or severe, acute or chronic, is increased among the men who are weakened in general health by hookworm infection, as shown by the general trend in the detailed data and by the final totals. The *direction of the differences* in morbidity detected between men with hookworm infection and those presumably without it, are of prime significance; the amplitude of these differences as here computed, is subject to varying degrees of error.

In October, 1916, the prevalence of illness and disease among certain organizations on the Mexican border, aroused the army surgeons to a preliminary investigation by Foster and Sinclair (1916) to ascertain its cause. At Nogales, Arizona, among 1,259 men, chosen at random from organizations composing a brigade of Alabama National Guard, 39.9 per cent. showed hookworm ova on a single stool examination. From October 24, 1916, to February 24, 1917, a period of four months, 84 per cent. of the 1st Alabama Infantry had been on sick call one or more times. During this same period 85.7 per cent. of the 4th Alabama Infantry were on sick call. In other words, the investigators found a very high incidence of sickness in a Brigade where hookworm was so prevalent. The present survey leads in the same direction, to the same general results, although it is much more comprehensive in its scope and significance, and involves larger numbers.

#### INCIDENCE OF DIFFERENT DISEASES.

The incidence of different diseases among men with hookworm ova in their stools shows, in the main, no striking evidence of heightened susceptibility to particular diseases (Table IV). The diseases that show a small percentage of increased incidence are tonsillitis, laryngitis, bronchitis, pneumonia, certain skin diseases, neurological affections, and of other miscellaneous acute infections, anthrax, erysipelas, cellulitis, peritonitis, chickenpox, septicaemia, and measles. The others show a percentage decrease, varying from minus 5.7 to minus 100. These latter are of less frequency and less importance in army economy.



TABLE IV.

*Incidence of different diseases in men with hookworm and in those in whom this was not detected, in the 36th Division, Camp Bowie, Texas.*

Diseases.	No hookworm detected.		Hookworm positive.		Per cent. increase or decrease among hookworm positives.
	Number.	Per cent. of disease.	Number.	Per cent. of disease.	
Respiratory:					
Asthma .....	12	0.12	1	0.01	— 91.6
Bronchitis .....	1,254	12.70	289	17.30	+ 36.2
Empyema .....	24	0.24	2	0.12	— 50.0
Influenza .....	1,130	11.40	171	10.20	— 10.5
Laryngitis .....	60	0.60	17	1.02	+ 70.0
Pleurisy .....	92	0.93	12	0.72	— 22.5
Pneumonia .....	739	7.40	136	8.10	+ 9.5
Pharyngitis .....	178	1.80	26	1.50	— 16.7
Rhinitis .....	119	1.20	9	0.54	— 55.0
Tuberculosis .....	37	0.39	2	0.12	— 69.2
Total .....	3,645	36.90	665	39.90	— 8.1
Gastro-intestinal .....	382	3.80	59	3.50	— 7.9
Constitutional, Diabetes, etc. ....	449	4.50	76	4.50	0
Cardio-vascular .....	25	0.25	2	0.12	— 52.0
Miscellaneous: Alcoholism, Cholecystitis, Hemorrhoids, etc. ....	705	7.10	68	4.10	— 42.3
Genito-urinary .....	460	4.60	61	4.00	— 13.0
Skin Diseases .....	28	0.28	6	0.36	+ 28.9
Neurological .....	34	0.34	25	1.50	+ 77.3
Special Senses					
Otitis Media, etc. ....	309	3.10	51	3.12	+ 0.6
Acute infections:					
Adenitis .....	24	0.24	2	0.12	— 50.0
Appendicitis .....	63	0.63	5	0.36	— 42.8
Anthrax .....	5	0.05	0	0	+ 100.0
Abscess .....	111	1.12	11	0.70	— 37.8
Arthritis .....	19	0.19	1	0.01	— 94.7
Cellulitis .....	54	0.55	10	0.60	+ 8.3
Cerebro-spinal meningitis .....	34	0.34	3	0.18	— 47.0
Chicken pox .....	6	0.06	2	0.12	+ 100.0
Diphtheria .....	6	0.06	0	0	— 100.0
Erysipelas .....	9	0.09	4	0.24	+ 166.7
Measles .....	612	6.20	130	7.80	+ 25.8
Mumps .....	2,095	21.20	333	20.00	— 5.7
Peritonitis .....	1	0.01	2	0.12	+1100.0
Rheumatism .....	177	1.70	27	1.60	— 5.9
Scarlet fever .....	14	0.40	2	0.12	— 70.0
Septicaemia .....	4	0.04	2	0.12	+ 200.0
Small pox .....	2	0.02	0	0	— 100.0
Tonsillitis .....	594	6.03	118	7.08	+ 17.4
Typhoid fever .....	3	0.03	1	0.01	— 66.7
Total .....	3,829	38.80	653	39.00	— 0.5

The classifications given are those found in the sick and hospital records. It is unfortunate that an examination of individual histories was not feasible. Unfortunately this survey, by its very volume, compelled the work to be extensive rather than intensive. Yet, as much emphasis was placed on the latter phase, as time and conditions would permit.

#### GENERAL DISCUSSION AND COMMENTS.

This survey for the detection of a possible relation between morbidity, mortality, and infection by hookworm in men comprising the 36th Division, at Camp Bowie, Texas, covers over 20,000 men through a period of nearly seven months, from October 1917 to April 1918. Those engaged in the investigation met with many difficulties and perplexities which tended to impair the accuracy of the work. No claim is made that the statistics compiled in this report are without errors. In fact there are some instances where reports available from regimental infirmaries were imperfect. In such instances an effort has been made to re-compile the data, correct the errors, or throw out altogether patent imperfections. In every instance where a choice has been open, we have thrown the weight of the evidence against hookworm, that is, to minimize, rather than exaggerate its importance. Hence conclusions reached have been based upon data conservatively compiled, where there was an option.

The greatest source of error doubtless arises from the necessity in each case of limiting the diagnosis of negative hookworm to an examination of one stool. As shown above this results in many light infections escaping detection and appearing in consequence in the list of negatives. For this reason we have used the phrase, "so-called negatives." The masking effect of the undetected positives cannot be measured from available data. We know neither their numbers nor the incidence of disease and death among them, nor have we any evidence as to whether or not light infections affect morbidity and mortality. The fact that total morbidity and mortality are higher in organizations with over 10 per cent. infection than they are in regiments with less than 10 per cent., may be due to the larger relative numbers of undetected positives in the former, or to heavier individual infections or quite probably to both factors in combination.

This investigation deals with many men from the margins of the hookworm area, in the period of life when the infections are dying

out, and with a group of men from which severe cases of hookworm disease have presumably been weeded out by medical examination at the time of enlistment or draft. The 36th Division was composed of National Guard troops supplemented by the earlier increments of the draft. Clinicians, treating men reported positive as a result of one examination, state that less than 10 per cent. of the men showed any noticeable clinical signs of the disease. The men in the great majority of the cases are carriers in light chronic phases of the infection and would not ordinarily be regarded as diseased by hookworm.

In the Division as a whole, and in most of the regiments and individual companies, the number of men becoming sick for any reason was greater among the hookworm carriers than in so-called negatives, being 27.9 per cent. of the total. Likewise, the tables show that the number of daily sick calls and admissions to hospitals were increased 88.6 per cent. and 76.5 per cent. respectively. These minor disturbances of health which cause a soldier to answer sick call, were thus more chronic among positives, inasmuch as the average calls per man were greater among them than the so-called negatives. The instances of men reporting sick to escape duty would presumably apply equally to positives and negatives, without much disturbing the relative values. In addition the greater number of hospital admissions per man, among positives, as compared with negatives, indicates that diseases were more severe in the former than in the latter. It is quite generally recognized that tuberculosis, malaria, and other chronic illnesses prove very stubborn or almost intractable to treatment in patients who have the additional handicap of hookworm infection. In fact, the intestinal tract must be cleared of parasites before the vital resources of the patient can be fully mobilized to arrest or obliterate disease efficiently. The facts in our data reveal the additional burden that was placed upon the Medical Corps of this Division by hookworm infection.

The available data here do not show very convincingly whether or not positives are more susceptible to the incidence of particular diseases than negatives. Yet it is of some value to note that respiratory diseases such as tonsillitis, laryngitis, bronchitis, and pneumonia, as well as measles, all of which exist very extensively in the army, were of greater incidence in this camp in men with hookworm than in men without. That the severity of disease is higher in positives than in negatives is shown by the 76.5 per cent. increase in hospital admissions, and by the fact that ten organizations having more than 10

per cent. hookworm infection, had a mortality rate of 1.5 per cent., 87 per cent. above that of seven others with lighter infections, averaging 8 per cent.

Wherever data in our records are large enough to reduce ordinary sources of error, whether we consider incidence, type in some instances, severity, chronicity, or mortality of disease, the frequency is as a rule greater in men with hookworm than in so-called negatives. That is, the direction of the difference in these particulars throws the burden of disease and its consequences onto men known to have hookworm infection.

All in all, those infections which are most common in army life and the easiest to diagnose, show a considerable increase among the hookworm hosts. Of the respiratory diseases, tonsillitis shows an increase of 17.4 per cent., laryngitis 70 per cent., bronchitis 36.2 per cent., pneumonia 9.5 per cent. and of the exanthemata, measles is 25.8 per cent. above the normal.

A survey was made by Cole and Siler (1917) of the 1st Mississippi Infantry and the 1st Alabama Cavalry, in which 1,710 recruits were examined for hookworm. Among 750 hookworm positives 136 cases of morbilli developed, while among 967 negatives only 63 cases of this disease occurred. In other words, there was an increase of 157.1 per cent. in measles among hookworm men. Complications, secondary to this eruptive disease, were 14 per cent. in positives and 8 per cent. in the so-called negatives, or an increase of 75 per cent. for those having the parasite. The same writers have shown that pneumonia was most prevalent among the men coming from the rural communities of the South. It is in these districts too, that hookworm infests the greatest percentage of the population.

It is obvious that immunity to measles is conferred only by a previous attack of the disease, and that the opportunities for this infection are greater in urban than in rural life. The figures cited from Cole and Siler are presumably to be explained by the isolation from infection by measles, in the troops of rural origin, and by the heavier incidence of hookworm consequent upon rural sanitation. In the absence of knowledge as to the number of measles susceptibles in the two groups of hookworm and non-hookworm men we find no evidence here that hookworm increased the susceptibility of its victims to measles infection. It may be expected to have increased the *severity* of the attacks among its victims so that they all came to observation and record, while in men without hookworm some of the



attacks may not have been so heavy, because of the absence of the infection.

It is highly probable that the incidence of other infectious and contagious diseases is not increased among hookworm victims by reason of their infection by this parasite. These diseases may, however, run a longer and severer course by reason of depleted resistance resultant from the toxæmia caused by this parasite. It may even be that an apparent increase in the *incidence* of diseases, such as those caused by light infections of the respiratory organs, may result from the fact that the increased severity brings them to the level of observation and of record more often in men with hookworm than in those without this infection. Men in both groups may be infected, but only the hookworm victim be "sick" enough to require and receive medical care, and thus be entered on the record, while the equally infected non-hookworm man recovers quickly and escapes medical care and record.

In a hookworm survey at Camp Sevier among the healthy soldiers, 18.6 per cent. were infected with hookworm. Among fatal cases of broncho-pneumonia, 50 per cent. were positive for hookworm, while among those that recovered, only 17 per cent. had the parasite. Since the percentage of hookworm among the recoveries was even less than the percentage of this infection among healthy men of this command, it is quite reasonable to regard hookworm as having a powerful influence against recovery from broncho-pneumonia.

Reports from Camp Jackson and Camp Wheeler state that in the former hookworm infection was present in about 30 per cent. of the command, and in the latter "many men suffered from anemia of hookworm." These camps, made up of Southern troops, show a similar prevalence and deleterious effects of hookworm infection that are brought out in this detailed survey of the 36th Division at Camp Bowie.

It is possible that the passage of hookworm larvae through the pulmonary capillaries into the alveoli during the period of invasion, renders the broncho-pulmonary tract more susceptible to disease. It is rather hazardous in the absence of controlled experiments, to venture a conclusion from statistical study whether or not such a lowering of resistance does occur. Should any pulmonary sensitization be present, it would of necessity be incurred during the "ground itch and snuffles" period. Practically all of these positives have long since passed beyond the stage of invasion and come under the classi-

fication of chronic carriers. Hence they might have developed a general lowering of resistance as well as this hypothetical local one. Whether one or both of these factors are at work requires extended clinical research. The statistics show that pneumonia is increased 9.5 per cent., bronchitis 36.2 per cent., and laryngitis 70.0 per cent. in those men with hookworm.

The incidence of tuberculosis shows a decrease of 69.2 per cent. among men harboring hookworm. At first glance it is difficult to understand why this disease should be so infrequent in these men. Yet this survey was conducted in the early period of mobilization, when the rigorous army life had had little time to affect those with less endurance. Any active or severe chronic tuberculosis would have been eliminated by the draft boards, at time of enlistment. The clinical picture of hookworm infection, plus active or severe pulmonary tuberculosis, would scarcely be overlooked in even the most cursory examinations and would result in rejection of men with the combined infection. The same thing would occur in most of the chronic constitutional diseases.

#### MORTALITY AND HOOKWORM IN THE 36TH DIVISION.

The tabulation of mortality, morbidity, and hookworm infection in the 36th Division from October 1, 1917, to April 1, 1918, shown in Table V, gives the complete data in parallel columns. The figures show no uniform increase in mortality among the regiments with the higher percentages of infection. In the 143d Infantry 30 per cent. of the men had hookworm ova in the stool examination, with 67.2 per cent. sick and a mortality of 2.8 per cent. This is twice, or more, the death rate of any other unit except the 131 M.G. Battallion and 2.3 times the average death rate of the whole division in this four month period. The 133d M.G. Battallion, with 21.2 per cent. hookworm infection and 62.9 per cent. of men sick, had a mortality of only one per cent. It is difficult to say why this heavily infected organization does not show a correspondingly high death rate, beyond the fact that it is a small organization. The former regiment had about five times as many men on roster, and over six times as many men with hookworm ova detected in their stools. It is the heaviest infected organization, and has the highest death rate in the Division.

There are ten of these organizations with 14,306 men examined which have a total hookworm infection of over 10 per cent. and seven

with 9,118 men examined with the infection below this figure. If the morbidity and mortality are compared in the two groups there is a definite preponderance of both sickness and death in the more highly infected group, as shown in Table VI.

TABLE V.

*Mortality, morbidity and hookworm infection in the 36th Division, at Camp Bowie, Texas, from October 1, 1917 to April 1, 1918.*

Organisation.	Total men on roster.	Mortality.		Total men with data.	Total men sick.		Total men exam. for hookworm.	Total men with hookworm.	
		No. dead.	Per cent.*		No.	Per cent.†		No.	Per cent.‡
141 Inf.....	2,589	36	1.4	2,263	1,015	44.9	2,521	295	11.7
142 Inf.....	3,189	22	0.7	2,837	1,497	52.8	3,010	295	9.8
143 Inf.....	3,165	89	2.8	2,905	1,951	67.2	2,983	895	30.0
144 Inf.....	3,306	46	1.4	2,965	1,172	39.5	3,032	368	12.1
131 F.A.....	1,380	13	0.9	1,380	945	68.5	1,357	143	10.5
132 F.A.....	1,449	4	0.3	1,235	307	24.9	1,266	144	11.3
133 F.A.....	1,571	20	1.3	1,455	558	38.3	1,452	163	11.2
131 M.G.Bn.....	387	9	2.3	385	184	47.8	365	37	10.1
132 M.G.Bn.....	721	2	0.3	702	262	37.3	692	63	8.8
133 M.G.Bn.....	697	7	1.0	645	406	62.9	658	140	21.2
111 Eng.....	1,517	18	1.2	1,521	722	47.5	1,495	132	8.8
111 Am.Tr.....	977	11	1.1	849	261	30.7	868	56	6.4
111 F.Sig.Bn.....	461	3	0.6	421	237	56.3	446	40	9.6
111 Sup.Tr.....	465	5	1.1	457	228	49.8	440	59	13.4
111 M.P.....	434	1	0.2	240	170	70.8	232	63	17.8
111 San.Tr.....	923	3	0.3	851	356	41.8	772	56	7.2
Miscellaneous.....	2,298	18	0.8	1,731	587	33.9	1,835	132	7.2
Summary.....	25,529	307	1.2	22,842	10,858	47.5	23,424	3,081	13.5

\* Per cent. mortality is based upon total men on roster.

† Per cent. of men sick is based on total men with data.

‡ Per cent. of men with hookworm is based upon the total number of men examined.

TABLE VI.

*Comparison of morbidity, total mortality, and that from pneumonia in organizations of the 36th Division with more or less than 10 per cent. infection by hookworm.*

	Above 10%.	Below 10%.
Total number of men examined .....	14,306	9,118
Total men with data .....	13,930	8,912
Total men on roster .....	15,443	10,086
Average hookworm infection .....	16.1%	8.5%
Morbidity (total men sick).....	69.2%	44.0%
Mortality .....	1.5%	0.8%
Mortality from pneumonias .....	1.3%	0.6%

It appears from this compilation that men in the more heavily infected organizations—above 10 per cent.—(average 16.1 per cent.), have a morbidity (total men sick) of 69.2 per cent., as compared with 44 per cent. in organizations with less than 10 per cent. hookworm infection (average 8.5 per cent.). An increase of 89 per cent. in hookworm infection (from 8.5 to 16.1 per cent.) is accompanied by a 57 per cent. increase in morbidity (from 44 to 69.2 per cent.). In like manner the total mortality rises from a ratio of 0.8 per cent. to 1.5 per cent. with an increase of hookworm infection from 8.5 to 16.1 per cent. An increase of 89 per cent. in the incidence of hookworm is accompanied by an increase of 87.5 per cent. in the total mortality. The total deaths from pneumonia in organizations with 8.5 per cent. hookworm were 64 or 0.6 per cent. In those organizations with 16.1 per cent. hookworm they were 204 or 1.3 per cent. An increase of 89 per cent. in hookworm infections is paralleled by an increase of 117 per cent. in deaths from pneumonias.

TABLE VII.

*Comparison of mortality from pneumonias in the 143d Infantry, and the remainder of troops at Camp Bowie.*

Number of men on roster.		Per cent. of men examined, infected with hook- worm.	Deaths from pneu- monias.	Per cent. mortality for pneu- monias.	Deaths from all causes.	Total deaths.	Per cent. total mortality.
143d Infantry.....	3,165	30.0	81	2.6	89	170	5.4
Remainder at Camp Bowie.....	22,364	10.7	187	0.8	307	494	2.2

The most striking contrast appears when the 143d Infantry is compared with the rest of the Division, in the matter of rate of mortality from pneumonias. This regiment with 2,589 men on its rosters, at the time of our hookworm survey had 81 deaths from pneumonias. With 10.1 per cent. of the men of the Division on its rosters, it had 30.2 per cent. of the deaths from pneumonias. The mortality rate from these diseases in this regiment with 30 per cent. hookworm was 2.6 per cent., as compared with 0.8 per cent. in the rest of the Division with 10.7 per cent. hookworm, an increase in the rate, of 325 per cent. A 284 per cent. increase in the 143d Infantry in the rate of infection by hookworm above that in the rest of the Division, was accompanied

by a 325 per cent. increase in the mortality from pneumonias in the regiment. The following summary presents the data utilized in arriving at these conclusions (Table VIII).

TABLE VIII.

*Morbidity and mortality from pneumonia in Army camps, six month's period, September 29, 1917, to March 29, 1918, and hookworm infection.*

Camp.	Army.	Annual rate per 1000.		Hookworm.					
		Mor- bidity rate.	Mortal- ity rate.	Camp.			Base hospital.		
				Per cent. in- fection.	Positive.	No. of men ex- amined.	Per cent. in- fection.	Positive.	No. of men ex- amined.
Bowie.....	N.G.	96	20.0	12.3	2,921	23,659	—	—	—
Wheeler.....	N.A.	95	23.6	76.4	873	1,143	25.4	63	248
Travis.....	N.A.	78	10.6	10.1	8,657	85,497	4.7	426	9,293
Pike.....	N.A.	63	24.9	2.8	31	1,095	10.7	68	637
Cody.....	N.G.	52	9.7	—	—	—	2.2	3	135
Beauregard....	N.G.	42	15.0	10.5	3,304	31,433	9.0	51	568
Taylor.....	N.A.	37	5.4	2.9	962	33,337	9.3	193	2,061
Sevier.....	N.G.	36	11.5	21.0	6,065	28,812	18.0	1,964	10,922
Jackson.....	N.A.	36	10.7	18.6	1,887	10,115	21.6	6,667	30,887
Doniphan.....	N.G.	33	9.0	—	—	—	—	—	—
Dodge.....	N.A.	29	5.3	4.2	167	4,024	.5	2	422
Funston.....	N.A.	24	10.5	1.6	6	371	—	—	—
Kearney.....	N.G.	24	4.4	1.1	10	871	—	—	7
Lee.....	N.A.	24	5.5	5.0	855	17,229	—	—	—
Shelby.....	N.G.	21	4.7	26.5	344	1,300	9.8	176	1,801
Meade.....	N.A.	18	2.6	—	—	—	10.3	27	262
Logan.....	N.G.	16	1.0	2.4	114	4,807	7.4	559	7,539
Gordon.....	N.A.	15	5.3	5.6	268	4,743	5.7	33	576
Sherman.....	N.A.	15	2.5	0.5	20	4,175	6.0	27	446
Upton.....	N.A.	15	3.6	—	—	325	—	—	3
Grant.....	N.A.	14	1.5	—	—	—	1.9	54	2,764
Lewis.....	N.A.	11	1.5	1.9	61	3,157	—	—	—
Devens.....	N.A.	9.8	2.0	—	—	—	15.2	835	5,479
McClellan....	N.G.	9.6	1.1	4.9	24	491	18.9	180	955
Sheridan.....	N.G.	9.3	1.7	2.8	48	1,712	4.7	61	1,286
Wadsworth....	N.G.	9.1	1.1	12.9	2,302	17,795	15.2	2,908	19,059
Dix.....	N.A.	8.0	1.5	4.1	234	5,661	16.0	4	25
Custer.....	N.A.	7.0	1.5	1.2	43	3,749	4.3	9	209
Hancock.....	N.G.	6.7	1.1	39.9	2,991	7,502	34.3	394	1,150
Totals.....				11.0	32,187	293,003	15.2	14,704	96,734

## COMPARISON WITH OTHER CAMPS.

In a comprehensive summary of the conditions of health in troops of the National Guard and National Army for the six months from September 29, 1917 to March 29, 1918, by Col. V. C. Vaughan, M.C., and Captain G. T. Palmer, S.C., there appears a graphic presentation

of the comparative mortality and morbidity in 29 camps, which we here reproduce (Fig. 1), with the addition of hookworm infection in each. In this there are plotted the total deaths, hospital admissions, and deaths from tuberculosis, diphtheria, and morbidity from pneumonia, measles, meningitis, scarlet fever, typhoid and paratyphoid, malaria, and venereal disease.

The most striking feature of the ensemble is the greater incidence of disease and death in camps with Southern troops, than in those with Northern. This is shown especially by the higher levels attained by the total death rate, by hospital admissions, and morbidity by pneumonia and measles. The authors note that negroes and Southern whites were more susceptible to pneumonia, than Northern whites, and then state the following: "It is an opinion generally held by medical officers in Southern camps that hookworm disease and chronic malarial infection increases susceptibility to the acute respiratory diseases. The information we have on these points is not as full as desirable."

From data compiled for the parasitological section of the proposed Medical History of the War, we are now able to supply data, showing the relative percentages of infection by hookworm in the camps with which these authors were dealing, with some exceptions. Among Northern troops little or no hookworm would be expected. Some enters with migrants from the South and with immigrants from the South of Europe and elsewhere from the hookworm area. Such data as are available in the statistics in this field indicate less than 1 per cent., a merely nominal infection among men enlisting from the North.

We have added in these graphs in a column at the left of the graph for each camp, the percentage of infection by hookworm, plotted on the basis of 100 for the highest rate, as reported to the Surgeon General's Office. The reports of examinations of patients in base hospitals are used in certain instances where they are more representative, than the percentage reported for the camp, as in the case of Camp Pike. A full list of the number of men examined, the number of positives and percentages of infection in camp surveys and hospital patients, wherever these data are available will be found in Table VIII. It is to be regretted that not all camps with Southern troops are represented, and that the data from some are inadequate.

Furthermore the data of Colonel Vaughan's table pertain to troops in camp at a period of about three to six months or even more in some cases, earlier, than the period of hookworm surveys in some

# **HOOKWORM AND COMPARATIVE MORTALITY AND MORBIDITY AT NATIONAL GUARD AND NATIONAL ARMY CAMPS FOR 6 MONTHS PERIOD SEPT. 29, '17 - MAR. 29, '18.**

*Plotted on basis of 100 for highest rate in each cause*

- 1 Deaths All Causes  
2 Admissions  
3 Deaths from T<sub>b</sub>  
4 Deaths from Diphtheria

- Order of Columns*  
Morbidity from -  
5 Pneumonia  
6 Measles  
7 Meningitis

- 8 Scarlet Fever  
9 Typhoid and Para Typhoid.  
10 Malaria  
11 Venereal Disease.

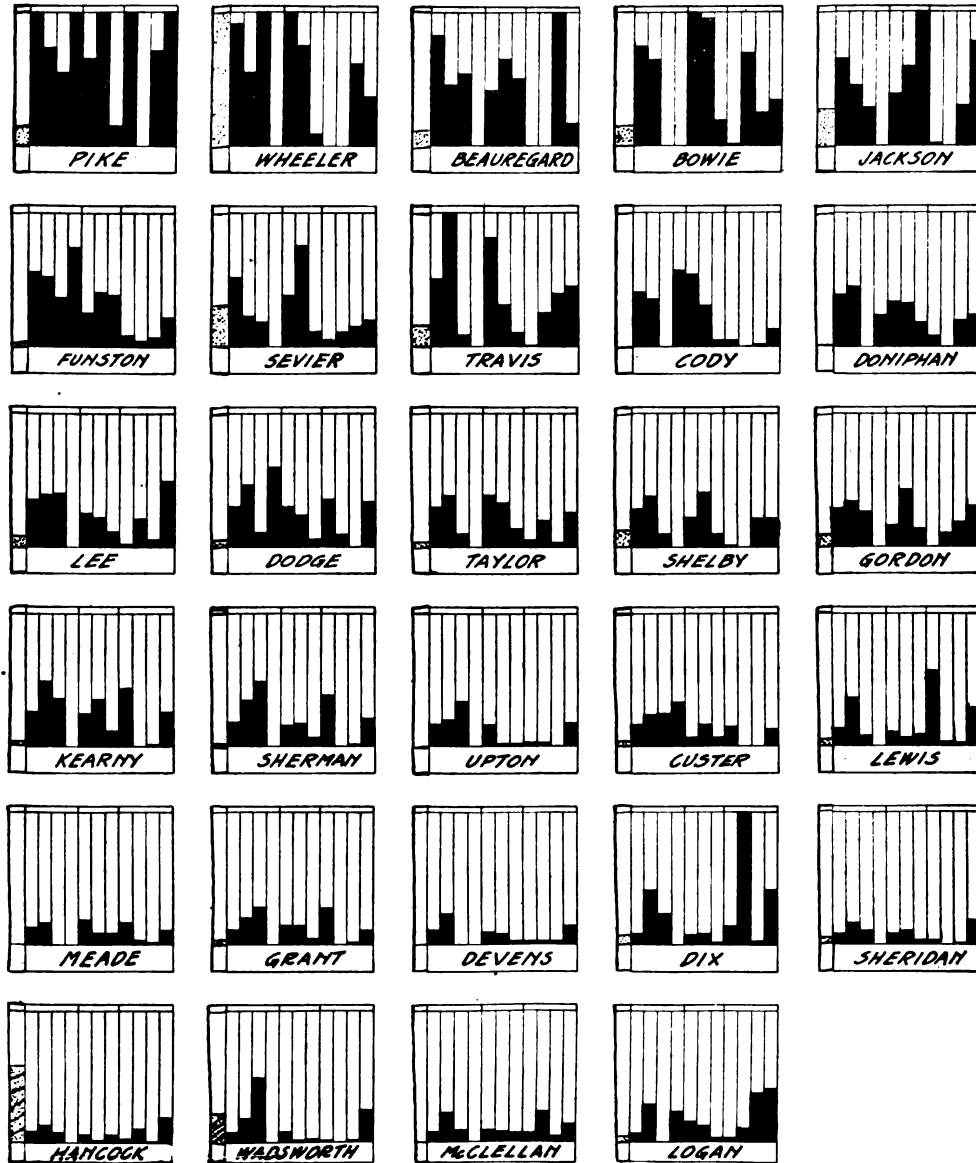


FIG. 1.



instances, and therefore deal largely with more or less different bodies of men from those surveyed for hookworm. Thus, Camp Wadsworth had New York men earlier and Southern men later, reported in the hookworm survey. Similarly Camp Hancock had Pennsylvania men earlier, but the data on hookworm refer only to a survey at a later date of Southern men therein. In fact, in all camps the men surveyed for hookworm are mainly either Southern men or Northern men with at least six months' Southern service. In camps reporting large numbers surveyed for hookworm the data pertain to a large number of the same men included in Colonel Vaughan's table, and more of a common period than when smaller numbers are reported.

There is, however, no clear suggestion that the rate of morbidity and mortality is proportional to the rate of hookworm infection among the more heavily infected camps. Thus Camp Bowie, with 12.3 per cent. (13.5 per cent. for men with sick data) infection, has about the same record for pneumonia and for total morbidity and mortality as Camp Wheeler, in which, (on very limited data) the percentage of infection was 25.4 (patients) or 76.4 (troop survey). In the cases of Camp Travis and Camp Jackson the numbers surveyed for hookworm were adequate, and the methods comparable. The former had the lower rate of hookworm infection (10.1 per cent.), but the higher rate of hospital admissions, and incidence of pneumonia (78 as compared with 36). The mortality rate in pneumonia was approximately the same in both camps (10.6 and 10.7); the total mortality was, however, greater in Camp Jackson, but not in proportion to the higher hookworm infection.

The percentages of infection by hookworm, as compiled from available army data in troops from North Carolina and South Carolina, which contributed to Camp Jackson, S. C., were 31.8, 29.0 and 23.6 respectively, while those in Texas and Oklahoma contributory to Camp Bowie were 11.7 and 7. The intensity of infection was also heavier in the individual among men at Camp Jackson, as shown by

FIG. 1. Reproduced from Chart 3, Vaughan and Palmer (1918), with the addition of the percentages of hookworm infections drawn either from Camp surveys or routine examinations at Base Hospital, using in each case the most representative determination. These percentages are plotted, as in the other entries on the plot, proportionately on the basis of the highest record, which was 76.4 per cent. at Camp Wheeler. In the case of Camps Wadsworth and Hancock the hookworm surveys deal with an entirely different group of men, of southern origin in the main, while the data concerning pneumonia were gathered while northern troops predominated in the camps.

the finding of 53 worms per infected man, by Major Barber, in 22 men on autopsy at that camp, and of 155 worms per man, in the stools, among 69 whites on treatment. We have no autopsy data at Camp Travis, but in 70 men, whose stools were examined on treatment, the number of worms was less than 5 per man.

In Kelly Fields 1 and 2 the percentage of infection in 2,575 men was 10, and on the examination there of the stools of 267 men at treatment only 8 worms per man were recovered, and in 201 of the discharged only 5 worms or less. These light percentages and intensity were due to the preponderance of Texas and Oklahoma men and to the urban life, social status and other limiting factors among the Southern men from other states attached to the Air Service.

In the face of the lighter percentages and intensities in Camps Travis and Bowie, as compared with Camp Jackson, we find a heavier incidence of pneumonia, and as high or higher mortality therein, than in the more heavily infected men at Camp Jackson. Other factors than hookworm are doubtless operative to produce this relationship. Insofar as any significance attaches to these variations in percentages and intensity of hookworm infection it would appear that light infections may be as potent as heavy ones in inducing whatever sensitization to pneumonia exists, as a result of the parasite or its supposed toxins.

However, if we divide the more significant camps into two lists, the one including all camps reporting a higher rate of infection by hookworm than 10 per cent. and the other those with less than 10 per cent., we find the following groupings:

TABLE IX.

*More than 10 per cent. infection by hookworm.*

	Source of troops.	Per cent. hook- worm.	Pneumonia (rate per 1,000).		Location of camp.
			Morbid- ity.	Mortal- ity.	
Camp Bowie.....	Ark., La., Miss.	12.3	96	20.0	Texas
Camp Wheeler....	Ala., Ga., Fla.	76.4	95	23.6	Georgia
Camp Travis.....	Okla., Texas	10.1	78	10.6	Texas
Camp Pike.....	Ala., La., Ark., Miss.	10.7	63	24.9	Arkansas
Camp Beauregard.	Ark., La., Miss.	10.5	42	15.0	Louisiana
Camp Sevier.....	N. C., S. C., Tenn.	21.0	36	11.5	South Carolina
Camp Jackson....	Fla., N. C., S. C.	18.6	36	10.7	South Carolina

*Less than 10 per cent. infection by hookworm.*

Camp Cody.....	Ia., Minn., Neb., S. D.	2.2	52	9.7	New Mexico
Camp Taylor.....	Ill., Ind., Ky.	2.9	37	5.4	Kentucky
Camp Lee.....	Pa., Va., W. Va.	5.6	24	5.5	Virginia
Camp Logan.....	Ill.	2.4	16	1.0	Texas

The percentages of infection by hookworm in the second group apply in the main, in these camps, to men from the South, or to those who were in the hookworm area for more than six months. They do not in most cases represent the total camp population. A reference to Table VI will show more fully the nature of the data. The contrast between the two groups is striking. Heavy infection by hookworm is accompanied by heavy incidence, and heavy mortality by pneumonia. Camp Logan, located in the same general territory with Camps Travis, Bowie, and Beauregard, but filled with Northern troops in the main, had but 14, 21, and 38 per cent. respectively of the incidence and 5, 9, and 7 per cent. of the mortality by pneumonia, which these three camps, filled with Southern men from the hookworm area, exhibited.

A somewhat closer comparison of the incidence of hookworm and pneumonia in Northern and Southern men can be obtained, if the data are compiled by states instead of by camps. This is presented in Table X in which the incidence of pneumonia and measles is compiled, on the basis of nativity, and that of hookworm infection, on the basis of state of enlistment or residence. Although the bases of compilation are not strictly comparable, they are sufficiently so to be significant, since nativity and residence as to state, are coincident in the majority of cases. In the matter of the Northern men examined for hookworm, the data are mainly from men who had had six months or more of army service or residence in the South. The percentages of infection reported therefrom from Northern states arise from two sources, men of Southern birth or residence enlisting from the North, or Northern men with exposure in the Southern hookworm area. The percentages of infection reported from the Northern states, in consequence of these facts, are without doubt, abnormally increased, and should be interpreted only as indicating the *number* of men reported in those states, not as the *percentages*, for no adequate representation of Northern men, as a whole, is available. In an inspection of the data arranged by states (Table X), it is at once evident that the

TABLE X.

*Lobar pneumonia, broncho-pneumonia, measles, and hookworm infection among U. S. troops according to nativity—Enlisted men.*

State of birth.	Annual admission rate per 1000.			Hookworm.		
	Lobar pneumonia.	Broncho-pneumonia primary.	Measles complicated.	Per cent.	Positive.	No. men examined.
Alabama.....	.233	.029	1.35	29.4	656	2,223
Alaska.....	—	—	.08	0	0	1
Arizona.....	.049	—	.22	3.1	4	128
Arkansas.....	.128	.065	1.36	6.4	787	12,292
California.....	.045	.013	.34	2.1	11	527
Colorado.....	.043	.015	.26	2.4	9	368
Connecticut.....	.028	.006	.08	1.5	4	265
Delaware.....	.020	.015	.13	8.7	2	23
District of Columbia..	—	—	—	1.6	2	121
Florida.....	.381	.042	1.45	31.8	1,202	3,778
Georgia.....	.153	.029	.88	32.6	1,265	3,872
Idaho.....	.043	—	.15	2.6	1	38
Illinois.....	.054	.008	.27	1.5	17	1,153
Indiana.....	.060	.017	.57	1.7	10	582
Iowa.....	.088	.010	.43	0.5	2	418
Kansas.....	.104	.013	.75	0.8	3	354
Kentucky.....	.111	.016	.82	16.3	376	2,301
Louisiana.....	.122	.056	1.14	27.3	2,010	7,348
Maine.....	.027	.008	.31	0.9	2	216
Maryland.....	.035	.009	.11	2.1	12	584
Massachusetts.....	.027	.004	.09	1.1	9	813
Michigan.....	.038	.007	.23	1.0	7	665
Minnesota.....	.043	.006	.21	1.5	5	325
Mississippi.....	.131	.038	1.26	27.1	2,358	8,684
Missouri.....	.101	.015	.61	1.8	41	2,326
Montana.....	.009	.001	.19	1.2	1	81
Nebraska.....	.128	.011	.49	0.9	3	345
Nevada.....	.049	—	.11	8.3	2	24
New Hampshire.....	.035	.012	.16	4.2	2	47
New Jersey.....	.022	.008	.06	0.3	1	284
New Mexico.....	.046	.018	.23	2.6	9	345
New York.....	.025	.006	.07	0.7	11	1,479
North Carolina.....	.056	.015	.79	27.2	3,402	12,558
North Dakota.....	.033	—	.22	0	0	82
Ohio.....	.042	.009	.18	3.5	45	1,277
Oklahoma.....	—	—	—	6.9	607	8,686
Oregon.....	.042	.009	.31	2.5	2	81
Pennsylvania.....	.030	.006	.08	0.4	4	1,074
Rhode Island.....	.018	.007	.04	1.4	1	73
South Carolina.....	.079	.018	.66	23.6	1,918	8,135
South Dakota.....	.053	.005	.32	1.6	1	63
Tennessee.....	.099	.027	1.21	12.3	1,233	9,722
Texas.....	.231	.054	1.58	11.7	3,494	29,837
Utah.....	.032	.005	.21	3.3	2	61
Vermont.....	.005	.002	.40	1.2	1	84
Virginia.....	.039	.011	.36	6.5	65	969
Washington.....	.059	.005	.11	2.2	3	137
West Virginia.....	.030	.009	.28	3.7	36	972
Wisconsin.....	.050	.009	.44	0.7	2	278
Wyoming.....	.041	—	.25	0	0	41
Totals.....	.067	.014	.43	3.3	19,732	594,238

states furnishing troops in which the infection was high, say above 20 per cent., are the very ones in which the two types of pneumonia and measles were most or at least highly prevalent. These states are seven—Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina.

The remaining states in the hookworm area, Arkansas, Kentucky, Missouri, (Oklahoma data lacking), Tennessee, Texas, Virginia, and West Virginia, carry a lighter infection and run a lighter incidence of the diseases named with some exceptions.

The states outside the hookworm area run a much lighter incidence of this parasite, which, when recorded therein, is probably in most cases introduced by migration and immigration. They also exhibit a noticeably lighter incidence of the pneumonias and of measles than those of the states of the hookworm area, excepting Virginia and West Virginia in which both hookworm and the diseases named are very light. This appears in the fact that while the minimum record for lobar pneumonia in the hookworm area, excluding Virginia and West Virginia is .056 for North Carolina, it is surpassed outside that area in only five states, to wit, Indiana (.060), Iowa (.088), Kansas (.104), Nebraska (.128), and Washington (.059).

TABLE XI.

*Summary of percentages of hookworm infections and incidence of pneumonia and measles.*

	Lobar pneumonia.		Bronchopneumonia.		Measles.	
	Range.	Average per State.	Range.	Average per State.	Range.	Average per State.
Above 20 per cent. infection with hookworm, Ala., Fla., Ga., La., Miss., N. C., S. C. ....	.381-.056	.165	.056-.015	.032	1.45-0.66	1.07
Below 10 per cent., Ark., Ky., Mo., Tenn., Tex., Va., W. Va. ....	.231-.030	.105	.065-.009	.028	1.58-0.36	0.89
Total hookworm area ...	.381-.030	.134	.056-.009	.030	1.58-0.36	0.98
All other states. ....	.128-.005	.043	.018-.001	.008	0.75-0.04	0.024

So also in the case of the incidence of broncho-pneumonia, the minimum rate in the hookworm area, as above limited, which is .015 in Missouri, is exceeded outside that area in only three states, to wit, Colorado (.015), Delaware (.015), and Indiana (.017).

Lastly, in the case of the incidence of measles in the hookworm area, as above limited, the minimum rate which occurs in Missouri (0.61) is exceeded outside that area only in Kansas (0.75).

There appears to be a tendency for certain states, mainly in the north central region west of the Mississippi River, to run a higher incidence of pneumonias and measles than states in the hookworm area, namely, those with only light hookworm percentages.

The above summary (Table XI) shows the range and average per state of the rates per 1000 admissions for lobar and broncho-

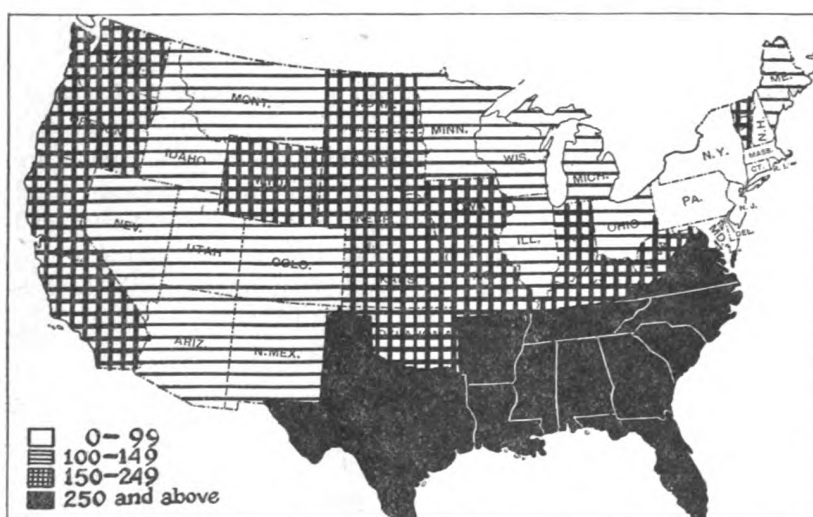


FIG. 2. Map of the United States showing the sum of admissions to sick report for primary lobar pneumonia; measles, simple or complicated; cerebrospinal meningitis and German measles. The chart gives for the different states the relative proportion of admissions to sick report which were for the named epidemic diseases. The table is drawn up by dividing the number of admissions in 1917 of the given diseases by nativity multiplied by 1,000 (Table 60, Surgeon General's Report, 1917), by the total admissions by nativity (Table 10, Surgeon General's Report, 1917). After Love and Davenport (1919, Fig. 8).

pneumonia and for measles in the group of seven heavily infected states, in seven with lighter infections, in the hookworm area as a whole (fourteen states), and in the remaining Northern and Western states. Both the magnitude and direction of the differences, support in every instance the hypothesis that there is some correlation between the incidence of hookworm and that of pneumonia and

measles and suggest that the percentage of men infected, which appears to have a correlation with the intensities of their individual infections, is roughly proportional to the rate of admissions. In this connection we again revert to our recognition of the fact that hookworm infection is only one of a complex of factors, not the sole factor involved in this correlation. The data here presented in supplement to Colonel Vaughan's, strongly support the hypothesis of a correlation and offer a quantitative measure of it. In the first winter of the war, troops from the hookworm area had about three times the admissions (to army hospitals) for lobar pneumonia, and nearly four times those for broncho-pneumonia and for measles, than troops from outside that area.

TABLE XII.

*Per cent. of urbanity in states of hookworm area, urban north, and rural western regions. Arranged from Davenport and Love (1919, Table 6).*

Hookworm area.	Urban north.	Rural west.	Per cent. of urbanity.
Miss., Ark., N. C., S. C., Ala., W. Va., Okla.		S. D., N. D. (?), N. Mex., Nev.	10-19.9
Tenn., Ga., Va., Tex., Ky., Fla.		Ida., Neb., Kan., Wyo.	20-29.9
La.	Iowa	Ariz., Mont.	30-39.9
	Minn., Ind., Mo., Wisc., Mich., Vt., Del.	Ore., Utah	40-49.9
	Md., Me., Ohio, N. H.		50-59.9
	Pa., Ill., Calif.	Colo., Wash.	60-69.9
	N. J., N. Y.		70-79.9
	Conn.		80-89.9
	Mass., R. I., D. C.		90-100

In their exhaustive statistical study of immunity in urban recruits Love and Davenport (1919) conclude that life in urban communities produces a general resistance to disease of which the observed resistances to measles, mumps, lobar pneumonia, cerebro-spinal meningitis, and scarlet fever are only special instances. Their data and graphs exhibit in the main the heavier incidence of morbidity in the states of the hookworm area, as compared with that in the more urban northern states. It is, however, also significantly heavier in states in the hookworm area, than it is in the group of rural western states, whose degrees of urbanity are equivalent to or approach those of the states of the hookworm area, as shown in their figure 8 reproduced in our figure 2.



An examination of this figure and Table XII reveals clearly the fact that the sparsely populated rural states of the mountain region (except Wyoming) have a relatively low combined admission rate (below 149) for lobar pneumonia, measles, meningitis, and German measles, while the rural states of the hookworm area all have a high rate (in excess of 250), except the border states of West Virginia, Kentucky and Oklahoma, in which the percentage of infection by hookworm is relatively light. It appears from this contrast that hookworm may be the differential and potent factor contributing to this greater incidence in morbidity in the hookworm (rural) area, as compared with non-hookworm states, both rural and urban.

#### HOOKWORM AND INTELLIGENCE.

There is some quantitative evidence of the relation which these light infections, with which we are dealing to a considerable degree in Camp Bowie, bear to the mental status of recruits. An investigation of this relation was made by Major B. F. Pittenger and the senior author at Camp Travis, Texas, whose Depot Brigade received increments from the same territory from which the 36th Division at Camp Bowie was drawn. This deals with the comparative intellectual attainments of 9,254 men of the April, 1918, increments, including white and colored, literate (alpha test) and illiterate (beta test), those with hookworm and those reported negative for the infection.

This investigation has a bearing on the question of hookworm and morbidity, since it indicates intellectual inferiority of hookworm victims, as compared with apparent negatives. This inferiority is doubtless the result of a vicious circle of factors, of which hookworm is but one. As such it may operate by the action of the supposed toxins from the worm upon the central nervous system of the host. Action of the toxin upon the nervous system may also be a factor in this incidence of disease among hookworm subjects. The large size and relatively great volume of the glands opening into the buccal cavity of the hookworm, provide the basis for a relatively large secretion, whose absorption into the circulation brings this secretion in contact with the tissues of the central nervous system.

The following table (Table XIII) shows the number of men in the several classes enumerated above, the median of each group attained in the psychological test to which they were subjected, and the extent and percentage of mental deficiency, accompanying hookworm infection.

TABLE XIII.

*Comparison of psychological records of 9,254 recruits at Camp Travis, Texas, with reference to hookworm infection, in white and colored troops, and literate and illiterate groups.*

No. men.	Literacy.	Infection.	Race.	Alpha score. Weighted ratings. Median.	Beta score. Weighted ratings. Median.	Difference.		Stanford-Binet. Median.	Difference in score.
						Score.	Per cent.		
4,792	Literate	Negative	White	107.4	—	—	—	16.7	—
501	Literate	Positive	White	80.4	—	-27	-22.3	15.2	-1.5
823	Illiterate	Negative	White	—	47.1	—	—	13.0	—
131	Illiterate	Positive	White	—	40.9	-6.2	-13.2	12.1	-0.9
1,817	Literate	Negative	Colored	28.6	—	—	—	11.6	—
74	Literate	Positive	Colored	27.5	—	-1.1	-3.9	11.5	-0.1
1,060	Illiterate	Negative	Colored	—	20.0	—	—	10.6	—
52	Illiterate	Positive	Colored	—	16.9	-3.1	-15.5	10.9	-0.3

Both the test and the hookworm examination were given within approximately two weeks after arrival of recruits at Camp Travis, and prior to the treatment for hookworm. The results of the two types of examination are also expressed in terms of the common scale (Stanford-Binet) of the Manual of the Psychological Division, in years of mental development. It appears that the median alpha score of literate whites with hookworms, is 27 points or 22.3 per cent. below that of men in the same class in whom the infection was not detected, while in illiterates the difference in score is 6.2 or 13.2 per cent. In literate blacks, the difference is less, as might be expected, because of a relative racial immunity. The racial difference is more evident, if the results are reduced to the common scale (Stanford-Binet) in which the intellectual status is expressed in mental age. According to this, literate whites with hookworm are, in attainment, 1.5 years below those without it, and literate blacks only 0.1 year. Illiterate whites are only 0.9 of a year deficient and illiterate blacks 0.3, when infected with hookworm.

Compilation of the percentile distribution of scores, attained by positives and so-called negatives, shows that the mental deficiency in literate whites with hookworm, as measured by the falling off in score attained by ten groups of ten per cent. each, is proportionately somewhat the same for the uppermost ten per cent., as the successive groups below, there being a tendency, however, for the degree of the deficiency to increase as the scores fall. This is shown in the accompanying table and graph, in which the first entry shows the average

score of the uppermost ten per cent. of the men, and following entries successive ten per cents. (Table XIV).

The interpretation of the data is that men infected with hookworm belong to all classes of mental rating, but not wholly proportionately in all groups to those without the infection, the men with low scores

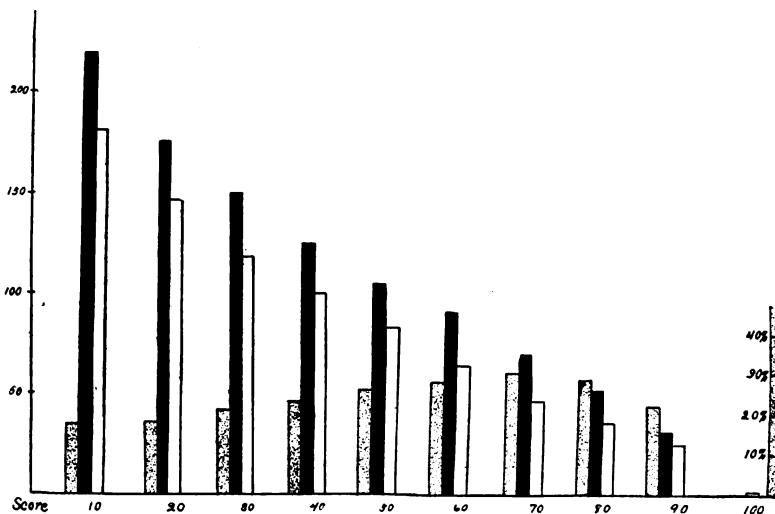


FIG. 3. Graphs showing percentage distribution of scores in psychological ratings of literate whites, of the April Increment in the 156th Depot Brigade, Camp Travis, Texas. The black column in the center of each group represents the median score of that percentage in men in whom hookworm had not been detected; the blank column at the right represents the median score for the corresponding percentage of men with hookworm, and the dotted column at the left represents the percentage which the deficiency in the score of the latter forms of the median score of the men without hookworm. The first group at the left thus represents the median score of the highest ten percentage, of the men without and of those with hookworm, and the deficiency of the latter in per cent. of the former. Succeeding groups represent successive ten percentages in similar fashion. The first ten percentages include the uppermost ten per cent. of each group, measured in terms of the psychological scores.

showing a greater relative deficiency as the score falls. It also appears that the infected men are pushed *en masse* below the normal by infection with hookworm, or by other factors correlated therewith in a vicious circle, but that the men with lower scores have a greater momentum, and move relatively farther from the norm, than do infected men with higher scores. This suggests the conclusion that

men with hookworm include a greater proportion of subnormal types than men without, and that subnormal men tend to acquire the disease more readily than men of higher categories. It is also possible that the intensity of individual infections may be heavier in the groups of lower intelligence, due to the relation of intelligence to sanitation, which in turn modifies the chance of infection and thus the ultimate intensity thereof.

TABLE XIV.

*Percentile distribution of scores of literate whites, with and without hookworm, and the deficiency in score in points and per cent. of April increments, 165th Depot Brigade, Camp Travis, Texas, compiled by Major G. F. Pittenger.*

Negatives.			Positives.		Mental deficiency.	
	Per cent.	Score.	Per cent.	Score.	Points.	Per cent.
Highest	10%...	219	10	181	38.0	17.4
2d	10.....	178.5	20	146.6	31.9	17.8
3d	10.....	150.6	30	118.6	32.0	21.2
4th	10.....	127.7	40	99	28.7	22.5
5th	10.....	107.4	50	80.4	27.0	25.1
6th	10.....	89.6	60	63.5	26.1	29.1
7th	10.....	70.7	70	48.7	22.0	31.1
8th	10.....	51.3	80	36.1	15.2	29.6
9th	10.....	31.8	90	24.6	7.2	22.6
Last	10.....	0.0	100	1	0	0

From the time a man with hookworm infection enters the army, until his cure or discharge from service, he becomes a distinct liability. He tends to lower the morale and efficiency of his organization by having less capacity for continued, prolonged, or heavy work, by acquiring and reacting less favorably to prevalent diseases, by being off duty more frequently, by greater liability to severe or fatal illness, and by greater tendency to delinquency. He can be relieved of the parasites in a short time without being on sick call for more than two days for treatment. The time, labor and expense of repeated stool examinations to detect infections, and treatment, are small in comparison with the burden that hookworm seemingly creates, and the work can be systematized much the same as has typhoid and cowpox inoculation. Examination and treatment, if needed, for all men entering the army, at least from the hookworm area, should be a matter of routine and permanent record.

Should this be done for recruits early in their army career, the increased efficiency of the organization as a whole, and of the men

individually, would fully justify the expenditure on grounds of cost, efficiency and morale.

Industrial enterprises in hookworm areas might raise the morale and increase the efficiency of their employees, and schools accelerate education by banishing hookworm.

#### SUMMARY.

1. This survey at Camp Bowie, Texas, utilized the results of an examination of one stool for hookworm ova from 22,842 men, with 3,079 or 13.5 per cent. reported positive, and 19,828 negative.

2. Among the men with hookworm, 1,767 were sick, with 4,993 appearances on sick call and 908 admissions to the hospital.

3. The so-called negatives had 9,091 sick with 17,494 sick calls and 3,421 admissions to the hospital.

4. The positives show an increase over the so-called negatives, of 27.9 per cent. in men sick, 88.6 per cent. in sick calls, and 76.5 per cent. in hospital admissions.

5. The same general direction of differences between men with and without hookworm appear in data obtained from the majority of individual companies making up the 141st Infantry and the 143d Infantry.

6. Positives for hookworm show an apparent increased susceptibility for tonsillitis, laryngitis, bronchitis, pneumonia, and measles. This is probably explainable as the result, in part, of rural isolation and resulting lack of immunities created by previous attacks, and by rural conditions favoring hookworm infection. The increased severity and chronicity of the respiratory infections in men with hookworm, as compared with men in whom the parasite was not found, may give rise to an apparent increase in susceptibility, or in "men sick," because light infections in men not having hookworm do not result in more than a temporary or a carrier phase of the infection, which wholly escapes medical attention and record.

7. The mortality in the ten heavily infected organizations, with hookworm above 10 per cent. is 1.5 per cent. In the seven more lightly infected organizations, with hookworm below 10 per cent., the death rate is 0.8 per cent., showing an increase in the more heavily infected group of 87.5 per cent. Morbidity and mortality from many causes, and the incidence of mortality from pneumonia, show a general correlation with the incidence of infection by hookworm, being higher as a rule wherever that infection is high.

8. The deaths from pneumonia in the 143d Infantry with 30 per cent. hookworm infection were 81, or 2.6 per cent., as compared with 187, or 0.8 per cent. in the remainder of the Division in which the infection by hookworm was 10.7 per cent. An increase of 284 per cent. in infection by hookworm in this regiment, as compared with the rest of the camp, is accompanied by a 325 per cent. increase in mortality by pneumonias.

9. Hookworm infections are relatively higher generally in hospital patients, among delinquents and in venereal isolation camps, than in camps, as a whole.

10. Troops from the hookworm area in army camps generally show a higher incidence of pneumonia and measles than do those from other regions. The incidence of these diseases is heavier in men from more heavily infected states, than in those from more lightly infected states.

11. Hookworm is one of a vicious circle of factors favoring inefficiency, morbidity, and mortality among army troops.

12. From the standpoint of economy and efficiency it would be more profitable to eliminate hookworm infection from every soldier, as he enters the service, than to allow him to continue untreated.

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